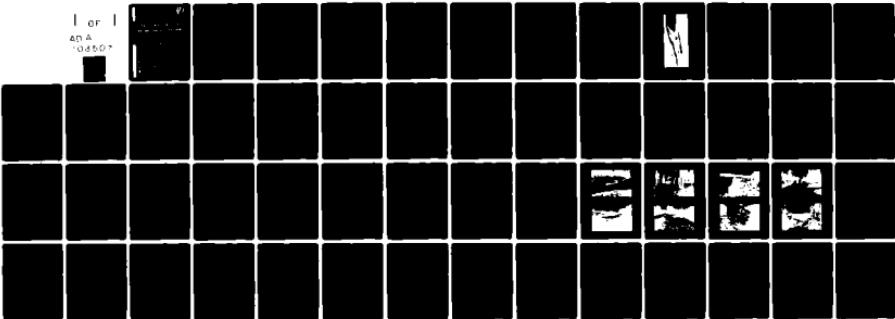


AD-A103 507      BAKER (MICHAEL) JR INC BEAVER PA  
NATIONAL DAM SAFETY PROGRAM, LAKE LAND' OR DAM (INVENTORY NUMBER--ETC(U)  
JAN 81 J A WALSH      DACW65-80-D-0032

F/G 13/13  
NL

UNCLASSIFIED

I or I  
RDA  
OXBOR



END  
DATE FILMED  
10-31-81  
DTIC

YORK RIVER BASIN

Name of Dam: Lake Land'or Dam

Location: Caroline County, Commonwealth of Virginia

Inventory Number: VA 03309

(1) BS

LEVEL II

AD A103507  
**PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM**

(6) National Dam Safety Program, Lake  
Land'or Dam (Inventory Number VA 03309)  
York River Basin, Caroline County,  
Commonwealth of Virginia. Phase I  
Inspection Report.



(7) Final copy

(11) Jan 1981

(10) James A. Welsh

DISTRIBUTION STATEMENT A

Approved for public release;  
Distribution Unlimited

PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS  
803 FRONT STREET  
NORFOLK, VIRGINIA 23510

(15) DACW65-X-8-D-NQ32

PREPARED BY  
MICHAEL BAKER, JR., INC.  
BEAVER, PENNSYLVANIA 15009

January 1981

40715

DTIC  
ELECTED  
SEP 1 1981  
S D  
D

FILE COPY  
BS

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
		AD-A103 507
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael Baker, Jr., Inc. Beaver, Penn 15009		8. CONTRACT OR GRANT NUMBER(s) DACW 65-80-D-0032 ✓
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineering District 803 Front Street Norfolk, Virginia 23510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE January 1981
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams - VA National Dam Safety Program Phase I Dam Safety Dam Inspection		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		

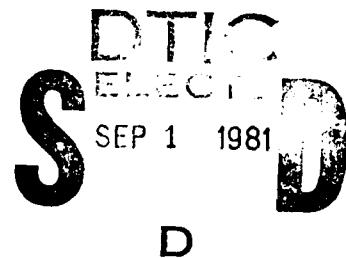
## 20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Inspection is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspection. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification _____	
By _____	
Distribution/ _____	
Availability Codes _____	
Avail and/or	
Dist	Special
A	



## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

CONTENTS

	<u>Page</u>
Preface . . . . .	i
Brief Assessment of Dam . . . . .	1
Overall View of Dam . . . . .	7
Section 1: Project Information . . . . .	9
Section 2: Engineering Data . . . . .	15
Section 3: Visual Inspection . . . . .	17
Section 4: Operational Procedures . . . . .	21
Section 5: Hydraulic/Hydrologic Data . . . . .	23
Section 6: Dam Stability . . . . .	27
Section 7: Assessment/Remedial Measures . . . . .	31

Appendices

- I. Plates
- II. Photographs
- III. Visual Inspection Check List
- IV. General References

NAME OF DAM: LAKE LAND'OR DAM

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake Land'or Dam  
State: Commonwealth of Virginia  
County: Caroline  
USGS 7.5 Minute Quadrangle: Ladysmith, Virginia  
Stream: Unnamed Tributary to South River  
Date of Inspection: 27 October 1980

BRIEF ASSESSMENT OF DAM

Lake Land'or Dam is an earthfill dam with an embankment approximately 2,159 feet long and 28.2 feet high<sup>1</sup>, and a 39.9 foot long concrete spillway. The dam, located in Caroline County, Virginia, is used to impound Lake Land'or for recreational purposes by the residents of the Lake Land'or Development Community. Lake Land'or Dam is an "intermediate" size - "significant" hazard dam as defined by the Recommended Guidelines for Safety Inspection of Dams. The dam and appurtenant structures appear to be in fair overall condition. Visual inspection of the dam revealed several minor deficiencies requiring further attention. A stability check of the dam is not required.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 1/2 Probable Maximum Flood (1/2 PMF) was selected as the spillway design flood (SDF). The SDF was routed through the reservoir and found to reach a maximum water surface elevation 1.3 feet above the top of the dam. The spillway is capable of passing up to 25 percent of the Probable Maximum Flood or 50 percent of the SDF without overtopping the crest of the dam. Therefore, the spillway has been adjudged as inadequate, but not seriously inadequate since there is not a high hazard to loss of life downstream of the dam from large flows. However, the 1/2 PMF could be detrimental to the dam stability, considering the disrepair of the downstream embankment.

A seep near the outlet of the emergency drain appears to be the result of deficiencies in the emergency drain. If repair items listed below do not stop this seep, a qualified geotechnical engineering firm should be retained to further investigate the problem and propose required remedial action.

<sup>1</sup>Measured from the streambed and the downstream toe of the embankment which are coincidental to the embankment crest, storage capacity 1190 acre-feet.

NAME OF DAM: LAKE LAND'OR DAM

A formal warning system and emergency action plan should be developed and implemented as soon as possible. A periodic inspection and maintenance program should also be developed and implemented as soon as possible.

The following repair items should be accomplished as part of the general maintenance of the dam:

- 1) Remove the small trees and fill the animal burrows on the downstream embankment.
- 2) Regrade, compact and reseed the downstream embankment.
- 3) Extend the riprap on the right side of the upstream embankment for 50 feet to protect the right dam abutment. Add riprap to the left side of the spillway channel for a distance of 70 feet to protect the left dam abutment.
- 4) Place proper size riprap on the right side of the spillway discharge channel.
- 5) Widen the outlet of the spillway discharge channel and remove all obstructions.
- 6) Excavate the outlet of the emergency drain and protect the area with support walls and riprap.
- 7) Install a staff gage to monitor reservoir levels above normal pool.
- 8) Relocate the boat dock situated upstream of the spillway.

NAME OF DAM: LAKE LAND'OR DAM

PRECEDING PAGE BLANK-NOT FILMED

MICHAEL BAKER, JR., INC.

SUBMITTED:

Original signed by  
JAMES A. WALSH

James A. Walsh, P.E.  
Chief, Design Branch

  
Michael Baker, III, P.E.  
Chairman of the Board and  
Chief Executive Officer



RECOMMENDED:

Original signed by  
JACK G. STARR

Jack G. Starr, P.E.  
Chief, Engineering

APPROVED:

Original signed by:  
Douglas L. Haller

Douglas L. Haller  
Colonel, Corps of Engineers  
District Engineer

Date:

JAN 30 1981

NAME OF DAM: LAKE LAND'OR DAM



OVERALL VIEW OF DAM

PRECEDING PAGE BLANK-NOT FILED

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
NAME OF DAM: LAKE LAND'OR DAM ID# VA 03309

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams (Reference 12, Appendix IV). The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: The Lake Land'or Dam is a 28.2 foot high<sup>1</sup> by 2,159 foot long earthfill embankment. The upstream and downstream slopes are approximately 4.3H:1V and 2.6H:1V (Horizontal to Vertical), respectively. The crest of the dam is 23 feet wide. The minimum top of dam, as determined from the field investigation, is elevation 233.2 feet Temporary Bench Mark (T.B.M.)<sup>2</sup>.

The upstream face of the embankment is protected by riprap extending down from the top of the embankment to a point below the normal water level. An 18 foot wide paved road runs across the entire length of the crest. The

<sup>1</sup>Measured from the streambed and the downstream toe of the embankment which are coincidental to the embankment crest.

<sup>2</sup>All elevations are referenced to a Temporary Bench Mark located on the right side of the spillway crest. The assumed elevation is 228.0 feet.

NAME OF DAM: LAKE LAND'OR DAM

PRECEDING PAGE BLANK-NOT FILMED

downstream face of the embankment is earthen with a sparse grass cover. A six foot deep cut-off trench and a clayey core were constructed as part of the earth embankment. No evidence of an internal drainage system for the dam was found.

The spillway is located approximately 80 feet from the left abutment. The spillway control section is a rectangular-shaped, reinforced concrete weir 39.9 feet wide by 4.0 feet deep by 0.73 feet thick. The crest of the weir is at elevation 228.0 feet T.B.M. The discharge channel, immediately downstream of the weir, is a paved concrete splash apron, 1.7 feet below the crest of the weir, with a bottom width of approximately 40 feet and side slopes of approximately 11.5H:1V. The concrete splash apron is approximately 31 feet long (Photo 1). The discharge channel downstream of the splash apron is a riprapped channel approximately 300 feet long and 40 feet wide. Flow from this channel is discharged into a swampy area along the toe of the dam, eventually entering South River approximately one half mile downstream.

The reservoir is fed by runoff from a small drainage area southwest of the dam. The upper two-thirds of the watershed is primarily woodland with some scattered farmland. The lower third of the watershed around the lake has been subdivided into residential and recreational lots. While present development is limited to just a few residences, the area has been subdivided into hundreds of lots, creating the potential for considerable residential development. In the area adjacent to the dam, recreational and storage facilities have been developed, including a boat ramp and dock located just upstream of the spillway. Campsites and camper storage areas have been developed along both sides of the spillway discharge channel at the left end of the dam (Photo 2). A skeet range, maintenance building, and boat storage area are located downstream of the right embankment.

An 18 inch bituminous coated corrugated metal outlet pipe has been installed through the embankment approximately 600 feet from the

NAME OF DAM: LAKE LAND'OR DAM

left abutment according to the developer's representative. The inlet of this pipe is located 75 feet offshore. An 18 inch gate valve with accompanying valve stem tower and hand wheel controls the discharge into the emergency drain. The invert at the outlet of the drain is at an approximate elevation of 203.5 feet T.B.M. The length and slope of the drain are estimated to be 240 feet and 2.5 percent, respectively.

- 1.2.2      Location: Lake Land'or Dam is located in Caroline County, Virginia approximately 2.5 miles west of Ladysmith, Virginia and approximately 0.8 miles north of VA Rt. 639. The dam is situated on an unnamed tributary to South River in the Lake Land'or Residential Community Project. A Location Plan is included in this report in Appendix I.
- 1.2.3      Size Classification: The height of Lake Land'or Dam is 28.2 feet and the reservoir storage capacity at the crest of the dam (elevation 233.2 feet T.B.M.) is 1,190 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.
- 1.2.4      Hazard Classification: A two-lane, tar and chip roadway runs along the crest of the dam. This road provides access to a portion of the Lake Land'or Development. Several camper storage areas, a boat storage area, a skeet range, and a maintenance building are located immediately downstream of the embankment. A campsite area is located adjacent to the left side of the discharge channel (Photo 3). Approximately 0.8 miles downstream of the dam, discharges from the dam flow through an 11-foot steel plate arch under Campers Lane. Approximately 2.5 miles downstream from the dam at the U.S. Rt. 1 bridge over South River, a housing development and trailer park are located on the left side of the river (Photos 7 and 8). The majority of these structures are built approximately 30 feet above the stream, but several are only 10 feet above the stream. Although loss of human life is not highly probable, damage to the recreational facilities downstream of the

NAME OF DAM: LAKE LAND'OR DAM

dam and to the bridges under Campers Lane and U.S. Rt. 1 is likely in the event of dam failure. Economic loss at the residences near the U.S. Rt. 1 bridge is also possible. Lake Land'or Dam is therefore considered in the "significant" hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and is not related to its stability or probability of failure.

- 1.2.5      Ownership: The dam is owned by the Lake Land'or Property Owners Association, Box 123, Ladysmith, Virginia 22501.
- 1.2.6      Purpose: The dam was constructed for recreational purposes.
- 1.2.7      Design and Construction History: According to information contained in the Inventory of Dams in the United States (Reference 11, Appendix IV) and conversations with the developer's representative, the dam was constructed in 1971 by J. R. Houston and engineered by Lake Land'or, Inc. The developer's representative indicated that the dam was constructed similar to Lake Heritage also located in the Land'or development and for which plans are available. The Lake Land'or Dam was constructed with borrow primarily obtained from the reservoir area. The embankment was reportedly constructed with a clayey core and a cut-off trench. A sheepfoot roller was used for compaction. No other information on design and construction history was available.
- 1.2.8      Normal Operating Procedures: The reservoir is normally maintained at the crest of the control section of the spillway at elevation 228.0 feet T.B.M. No formal operating procedures are followed for this structure.

### 1.3 Pertinent Data

- 1.3.1      Drainage Area: The drainage area tributary to the dam is 2.40 square miles.
- 1.3.2      Discharge at Dam Site: The maximum discharge from the reservoir occurred following Tropical

NAME OF DAM: LAKE LAND'OR DAM

Storm Agnes in June 1972 when water reached a depth of 2.96 feet (elevation 230.96 feet T.B.M.) in the spillway. The discharge which would produce this depth of flow in the spillway has been calculated to be approximately 676 cubic feet per second (c.f.s.).

The capacity of the spillway with the pool elevation at the top of the dam is 1,575 c.f.s.

- 1.3.3      Dam and Reservoir Data: Pertinent data on the dam and reservoir are provided in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation (feet T.B.M.)	Area (acres)	Reservoir Capacity		
			Acre- feet	Watershed (inches)	Length (feet)
Top of Dam (minimum)	233.2	131.7	1190	9.3	6300
Spillway Crest (normal pool)	228.0	91.8	612	4.8	4850
Streambed and downstream toe of dam <sup>1</sup>	205.0	-	-	-	-

<sup>1</sup>The streambed, tailwater, and toe coincide because of the swampy area at the emergency lake drain.

NAME OF DAM: LAKE LAND'OR DAM

## SECTION 2 - ENGINEERING DATA

- 2.1 Design: Design plans, specifications and boring logs were not available for use in preparing this report. No stability analyses or hydrologic and hydraulic data were available for review.
- 2.2 Construction: Construction records, as-built plans, and inspection logs were not available for review. However, conversations with the developer's representative and the dam construction manager, indicated that the dam was completed in 1971 by J. R. Houston. Although plans are not available, this dam was constructed similar to Lake Heritage Dam for which plans were reviewed. These plans showed very limited detail. According to the developer's representative, the dam was constructed with borrow obtained primarily from the reservoir area. The embankment was constructed with a clayey core and a six foot deep cut-off trench. A sheepfoot roller was reportedly used for compaction.
- 2.3 Evaluation: No construction records or as-built plans were available to adequately assess the condition of the dam. All evaluations and assessments in this report were based upon field observations, discussions with representatives of the owner, and office analyses.

NAME OF DAM: LAKE LAND'OR DAM

### SECTION 3 - VISUAL INSPECTION

#### 3.1 Findings

- 3.1.1 General: The field inspection was conducted on 27 October 1980. At the time of the inspection, the pool elevation was at 227.0 feet T.B.M.; the tailwater elevation was 205.0 feet T.B.M.; and the weather was clear with the temperature at 50 degrees Fahrenheit. The ground surface of the embankment and abutments was generally dry. The dam and appurtenant structures were found to be in fair to good overall condition at the time of the inspection. Deficiencies found during the inspection will require remedial treatment. The following are brief summaries of deficiencies found during the inspection. A field sketch of conditions found during the inspection is presented as Plate 1 in Appendix I. The complete visual inspection check list is included as Appendix III. No record of any previous inspections was found.
- 3.1.2 Dam: The embankment was found to be in generally fair condition. Vegetation on the downstream embankment is somewhat scarce, particularly on the lower half. The lower one half to one third of the downstream embankment is moderately eroded with numerous gullies, some as deep as two feet (Photo 6). A few small animal burrows are present and small saplings have seeded onto the downstream slope. The downstream embankment directly opposite the emergency sluice gate control is badly eroded. A continually flowing, clear seep has developed near the outlet of the emergency drain, which has been covered over by sediment eroded from the embankment. Flow of this seepage was estimated to be in excess of five gallons per minute (g.p.m.). The upstream embankment is riprapped to the crest of the dam (Photos 4 and 5). However, some minor erosion has occurred along the left side of the upstream embankment between the spillway and the left abutment.
- No evidence of an internal drainage system was found during the inspection.

NAME OF DAM: LAKE LAND'OR DAM

- 3.1.3     Appurtenant Structures: The spillway approach channel and splash apron are unobstructed and in good condition. Some moderate erosion has occurred along the right side of the riprapped discharge channel. The discharge channel is narrow and obstructed near the outlet.
- The support tower and stem for the emergency drain are badly corroded, unstable and may fail if operated. The outlet of the emergency drain is buried by material eroded from the embankment above.
- 3.1.4     Reservoir Area: The slopes surrounding the reservoir are very gentle and covered with a moderately thick cover of grass. An insignificant amount of minor erosion has occurred along the shoreline. Development along the shoreline consists of a few private boat docks scattered around the lake and a boat ramp and dock for general use located a short distance upstream from the spillway approach channel. A few homes are scattered sporadically along the lake shore.
- 3.1.5     Downstream Channel: The area immediately downstream of the embankment is swampy and brush covered, especially in the downstream area of the outlets of the spillway discharge channel and the emergency drain. The slope of the stream below the dam is extremely flat, approximately 0.1 percent, and the stream flows through swamps with heavy brush cover for about 1.5 miles. The absence of a distinct channel below the outlets of the spillway discharge channel and emergency drain appears to be a contributing factor to the swampy condition which now exists below the embankment.
- 3.1.6     Instrumentation: There is no instrumentation at the dam site.
- 3.2     Evaluation: In general, the dam and appurtenant structures are in fair to good condition. On the downstream embankment, the saplings should be removed and the animal burrows backfilled. The downstream embankment should then be regraded, compacted, reseeded, and mulched. The riprap on the upstream embankment should be extended another 50 feet on the right side to protect the abutment and more riprap should be added to the

NAME OF DAM: LAKE LAND'OR DAM

left side of the spillway approach channel for a distance of 70 feet. The erosion on the right side of the spillway discharge channel should be inspected and proper sized riprap installed. The outlet of the spillway discharge channel should be widened and all obstructions removed to prevent possible flooding of the campsites and camper storage areas located near the spillway discharge channel. The area around the emergency drain outlet should be excavated to uncover the outlet, and the outlet should then be protected by support walls and riprap to prevent further erosion. The boat dock situated just upstream of the spillway approach should be relocated to prevent any obstruction from occurring in the spillway during high flows. A staff gage should be installed to monitor reservoir levels above normal pool.

NAME OF DAM: LAKE LAND'OR DAM

## SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: The operation of the dam is an automatic function controlled by the crest of the spillway at elevation 228.0 feet T.B.M.
- 4.2 Maintenance of Dam: Maintenance of the dam is the responsibility of the owner. An inspection or maintenance schedule has not been instituted.
- 4.3 Maintenance of Operating Facilities: The only operating facility at the dam at the time of inspection is the emergency drain. The maintenance of this facility is the responsibility of the owner. An inspection, testing, or maintenance schedule has not been instituted.
- 4.4 Warning System: At the time of inspection, there was no warning system or emergency action plan in operation.
- 4.5 Evaluation: Past maintenance of the dam has been inadequate. Regular inspections should be made of the dam and appurtenant structures. A thorough check list should be compiled by the owner's representative as a guide for the inspections. Maintenance items should be corrected annually. A warning system and emergency action plan should be developed and put into operation.

NAME OF DAM: LAKE LAND'OR DAM

## SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

- 5.1 Design: No hydraulic or hydrologic design data were available for use in preparing this report.
- 5.2 Hydrologic Information: No rainfall, stream gage or reservoir stage records were maintained for this dam.
- 5.3 Flood Experience: The only high water mark noted since completion of the dam was following Tropical Storm Agnes in June 1972. The water reached an elevation of 230.96 feet T.B.M. which corresponds to a flow rate of 676 c.f.s. No additional records were available.
- 5.4 Flood Potential: The Probable Maximum Flood (PMF), 1/2 Probable Maximum Flood (1/2 PMF) and 100-year flood were developed and routed through the reservoir by use of the HEC-1 DB computer program (Reference 9, Appendix IV) and appropriate unit hydrograph, precipitation and storage-outflow data. Clark's  $T_C$  and R coefficients for the local drainage areas were estimated from the basin characteristics. The rainfall applied to the unit hydrograph was taken from publications by the U.S. Weather Bureau and the National Oceanic and Atmospheric Administration (References 16 and 17, Appendix IV). Rainfall losses for the PMF and 1/2 PMF were estimated at an initial loss of 1.0 inches and a constant loss rate of 0.05 inches per hour thereafter. Rainfall losses for the 100-year flood were estimated at an initial loss of 1.5 inches and a constant loss rate of 0.15 inches per hour thereafter.
- 5.5 Reservoir Regulation: Pertinent dam and reservoir data are provided in Table 1.1, Paragraph 1.3.3.
- Regulation of flow from the reservoir is automatic. Normal flows are maintained by the weir crest of the spillway which is at elevation 228.0 feet T.B.M.
- The outlet discharge capacity was computed by hand; reservoir area was planimetered from the Ladysmith, Virginia and Hewlett, Virginia, 7.5 minute USGS quadrangles; and storage capacity curves were computed to elevations above the crest of the dam. All flood routings were begun with the reservoir at normal pool.
- 5.6 Overtopping Potential: The probable rise of the reservoir and other pertinent information on reservoir performance are shown in the following table:

NAME OF DAM: LAKE LAND'OR DAM

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal <sup>1</sup>	Hydrographs		
		100-year flood	1/2 PMF	PMF <sup>2</sup>
Peak flow, c.f.s.				
Inflow	1.0	2518	6912	13,823
Outflow	1.0	888	6570	13,673
Peak elev., ft. T.B.M.	228.0	231.5	234.5	235.2
Non-overflow section <sup>3</sup> (elev. 233.2 ft. T.B.M.)				
Depth of flow, ft.	-	-	1.3	2.0
Average velocity, f.p.s.	-	-	5.3	6.6
Total duration of over- topping, hrs.	-	-	4.2	6.3
Tailwater elev., ft. T.B.M.	205.0	-	-	-

<sup>1</sup>Conditions at time of inspection.

<sup>2</sup>The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region.

<sup>3</sup>Velocity estimates were based on critical depth at control section.

5.7 Reservoir Emptying Potential: The reservoir can be drawn down by means of an 18 inch emergency drain. Neglecting inflow, the reservoir can be drawn down from normal pool in approximately 24.0 days. This is equivalent to an approximate drawdown rate of 0.8 feet per day, based on the hydraulic height measured from normal pool divided by the time to dewater the reservoir.

5.8 Evaluation: Lake Land'or Dam is an "intermediate" size - "significant" hazard dam requiring evaluation for a spillway design flood (SDF) in the range between the 1/2 PMF and the PMF. Due to the risk involved, the 1/2 PMF has been selected as the SDF. The SDF was routed through the reservoir and found to overtop the dam by a maximum depth of 1.3 feet with an average critical velocity of 5.3 feet per second (f.p.s.). Total duration of dam overtopping would be 4.2 hours. The spillway is capable of passing up to 50 percent of the SDF or 25 percent of the PMF without overtopping the crest of the dam.

NAME OF DAM: LAKE LAND'OR DAM

Conclusions pertain to present day conditions and the effect of future development on the hydrology has not been considered.

NAME OF DAM: LAKE LAND'OR DAM

## SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: No previous information was available for the visual inspection or subsequent analyses describing local subsurface conditions. The dam is located along the border separating the Piedmont and the Coastal Plain physiographic provinces. The topography of the Piedmont (probably the most applicable) generally consists of rolling hills and gentle slopes with relief less than 150 feet. Granite gneiss of uncertain age is shown on the State geologic map (Reference 4, Appendix IV) as underlying the dam. Highly weathered gneiss was observed in place along the lake shoreline near the left abutment during the visual inspection. It is not known specifically how the dam was keyed into the foundation and abutments. However, it is reported that a six foot deep cut-off trench was excavated using a pan. Relatively thick combination residual, alluvial soils are expected beneath the dam considering the wide, flat local topography. The Piedmont physiographic province is reported to contain widespread, thick (50-150 feet) residual soils.

### 6.2 Embankment

6.2.1 Materials: There was no information available for this inspection describing the nature of the embankment materials or any zoning within the dam except it is reported a clayey core was constructed. During the visual inspection, the outer embankment materials were determined to consist of reddish-brown sandy silt with a trace of clay (ML group soil-Unified Classification System). The embankment materials were reportedly obtained from the reservoir area. The local area soils are similar in nature, derived largely from weathering of the underlying gneiss.

6.2.2 Stability: Design plans and the results of a previous stability analysis were not available for use during this evaluation. Thus, the embankment is assumed to be a modified homogeneous type. The dam is 28.2 feet high with a crest width of 23 feet. The upstream slope of the dam is 4.3H:1V and the downstream slope is 2.6H:1V. Due to the availability of a reservoir drain, the reservoir could be drawn down in the event of an emergency. The

NAME OF DAM: LAKE LAND'OR DAM

dam is subject to a rapid drawdown of 0.8 feet per day which exceeds the critical rate of 0.5 feet per day for earth dams. According to guidelines outlined in Design of Small Dams (Reference 1, Appendix IV) by the U.S. Department of the Interior, Bureau of Reclamation, the upstream slope of a small modified homogeneous dam constructed of slightly plastic fine grained soils (ML, CL), with a stable foundation, should be 3.5H:1V if subject to rapid drawdown. The downstream slope recommended is 2.5H:1V. A crest width of 16 feet is recommended considering the height of the dam. Based upon these generalized guidelines, the dam has adequate crest width, upstream slope, and downstream slope.

Signs of instability in the embankment such as slumping, tension cracks, or unusual alignment along the crest were not observed during the visual inspection. The lower section of the downstream embankment was generally dry even though an internal drainage system was not provided. A clear water discharge of approximately 5 gpm was observed at the toe of the dam directly opposite the emergency drain control structure (see Plate 1). This discharge is considered to be seepage from the drain (the outlet of which is covered by sediment from erosion of the downstream slope of the embankment) rather than seepage through the dam. No other seepage was observed. The lower one half to one third of the downstream embankment is moderately eroded. Erosion gullies as deep as 2 feet are present.

6.2.3 Seismic Stability: The dam is located in Seismic Zone 2 which presents no hazard from earthquakes according to the Recommended Guidelines for Safety Inspection of Dams by the Department of the Army, Office of the Chiefs of Engineers. This determination is contingent on the requirements that static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: The results of a previous stability analysis were not available for comparison as part of this evaluation. The visual inspection revealed no signs of instability although continued erosion of the downstream

NAME OF DAM: LAKE LAND'OR DAM

embankment will be detrimental in this respect. The upstream and downstream slopes of the dam, as well as the crest width are more than satisfactory as compared to the Bureau of Reclamation guidelines. A stability check is not required.

Also, as described in Section 5 of this report, the dam would be overtopped by the SDF. The SDF would overtop the dam by a maximum depth of 1.3 feet with an average critical velocity of 5.3 f.p.s. Total duration of overtopping would be 4.2 hours. Overtopping flows during the SDF are relatively shallow, last 4.2 hours, and the velocity 5.3 f.p.s. does not exceed 6.0 f.p.s., the effective eroding velocity for a vegetated earth embankment. However, the depth, duration and rate of overtopping flows could be detrimental to the dam stability, considering the present eroded and sparsely vegetated condition of the downstream embankment.

NAME OF DAM: LAKE LAND'OR DAM

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: Information on this dam was inadequate. No construction plans, design specifications, as-built plans or any other engineering data for the dam were available for use in preparing this report. The dam and appurtenant structures were generally in fair overall condition at the time of the inspection. Deficiencies discovered during the field inspection and office analyses will require further investigation and remedial treatment. Maintenance of the dam is considered inadequate. Signs of instability were not observed and a stability check is not required.

A seep near the outlet of the emergency drain appears to be the result of deficiencies in the emergency drain. If repair items listed below do not stop this seep, a qualified geotechnical engineering firm should be retained to further investigate the problem and propose required remedial action.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 1/2 PMF was selected as the SDF for the "intermediate" size - "significant" hazard classification of Lake Land'or Dam. It has been determined that the SDF would overtop the dam by a maximum depth of 1.3 feet with an average critical velocity of 5.3 feet per second. Total duration of the overtopping would be approximately 4.2 hours. The spillway is capable of passing up to 25 percent of the PMF or 50 percent of the SDF without overtopping the non-overflow section of the dam. The spillway is adjudged as inadequate, but not seriously inadequate. The spillway has not been adjudged as seriously inadequate since there is not a high hazard to loss of life from large flows downstream of the dam. However, the 1/2 PMF could be detrimental to the dam stability considering the disrepair of the downstream embankment.

There is no warning system or emergency action plan currently in operation.

7.2 Recommended Remedial Measures: A formal warning system and emergency action plan should be developed and put into effect as soon as possible.

Regular inspections should be made of the dam and appurtenant structures. A thorough check list should be compiled for use by the owner's representative as a guide for the inspections. Maintenance items should be completed annually.

NAME OF DAM: LAKE LAND'OR DAM

The following repair items should be accomplished as part of the general maintenance of the dam:

- 1) Remove the small trees and fill the animal burrows on the downstream embankment.
- 2) Regrade, compact and reseed the downstream embankment.
- 3) Extend the riprap on the right side of the upstream embankment for 50 feet to protect the right dam abutment. Add riprap to the left side of the spillway channel for a distance of 70 feet to protect the left dam abutment.
- 4) Place proper size riprap on the right side of the spillway discharge channel.
- 5) Widen the outlet of the spillway discharge channel and remove all obstructions.
- 6) Excavate the outlet of the emergency drain and protect the area with support walls and riprap.
- 7) Install a staff gage to monitor reservoir levels above normal pool.
- 8) Relocate the boat dock situated upstream of the spillway.

NAME OF DAM: LAKE LAND'OR DAM

**APPENDIX I**  
**PLATES**

## **CONTENTS**

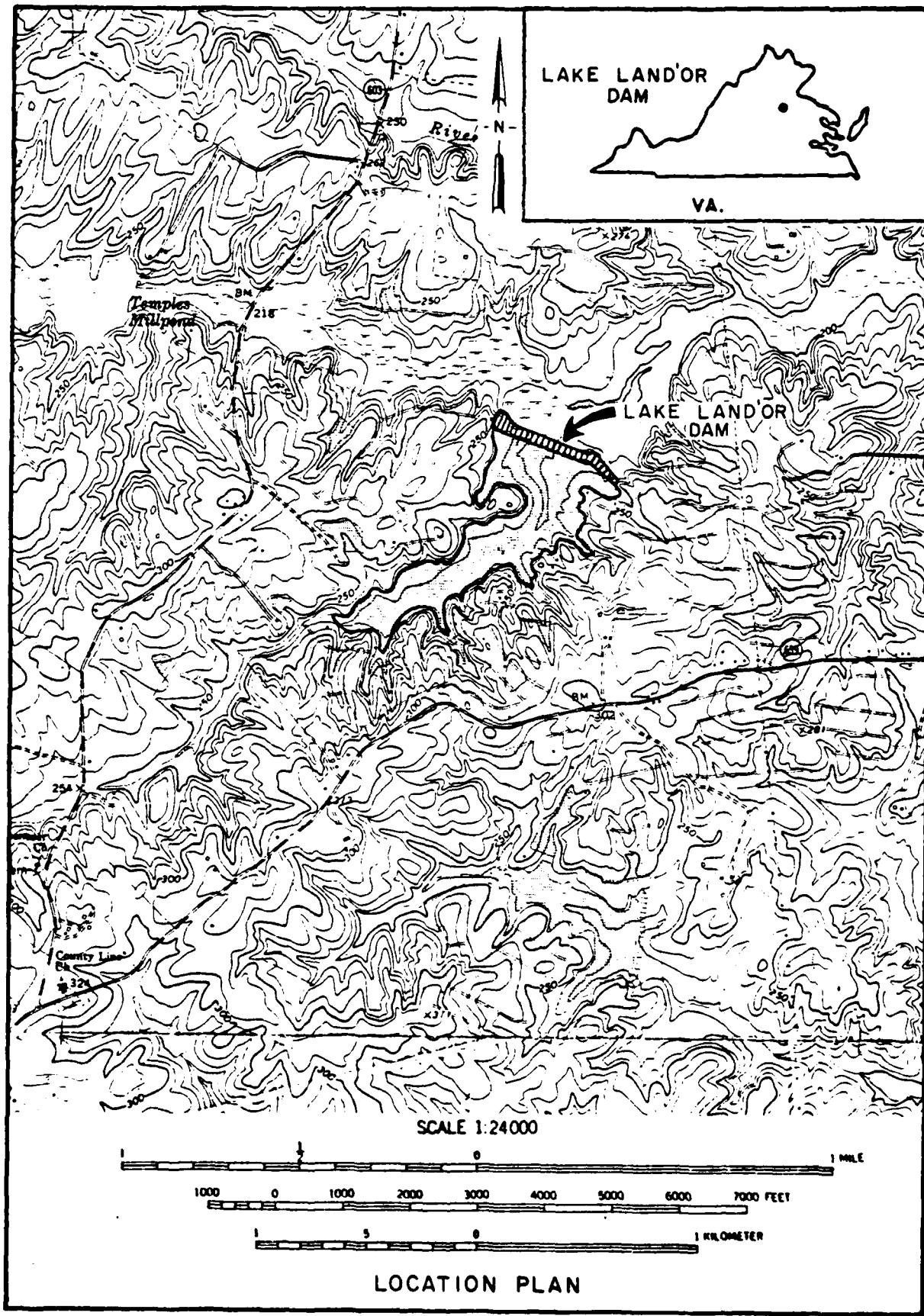
**Location Plan**

**Plate 1: Field Sketch**

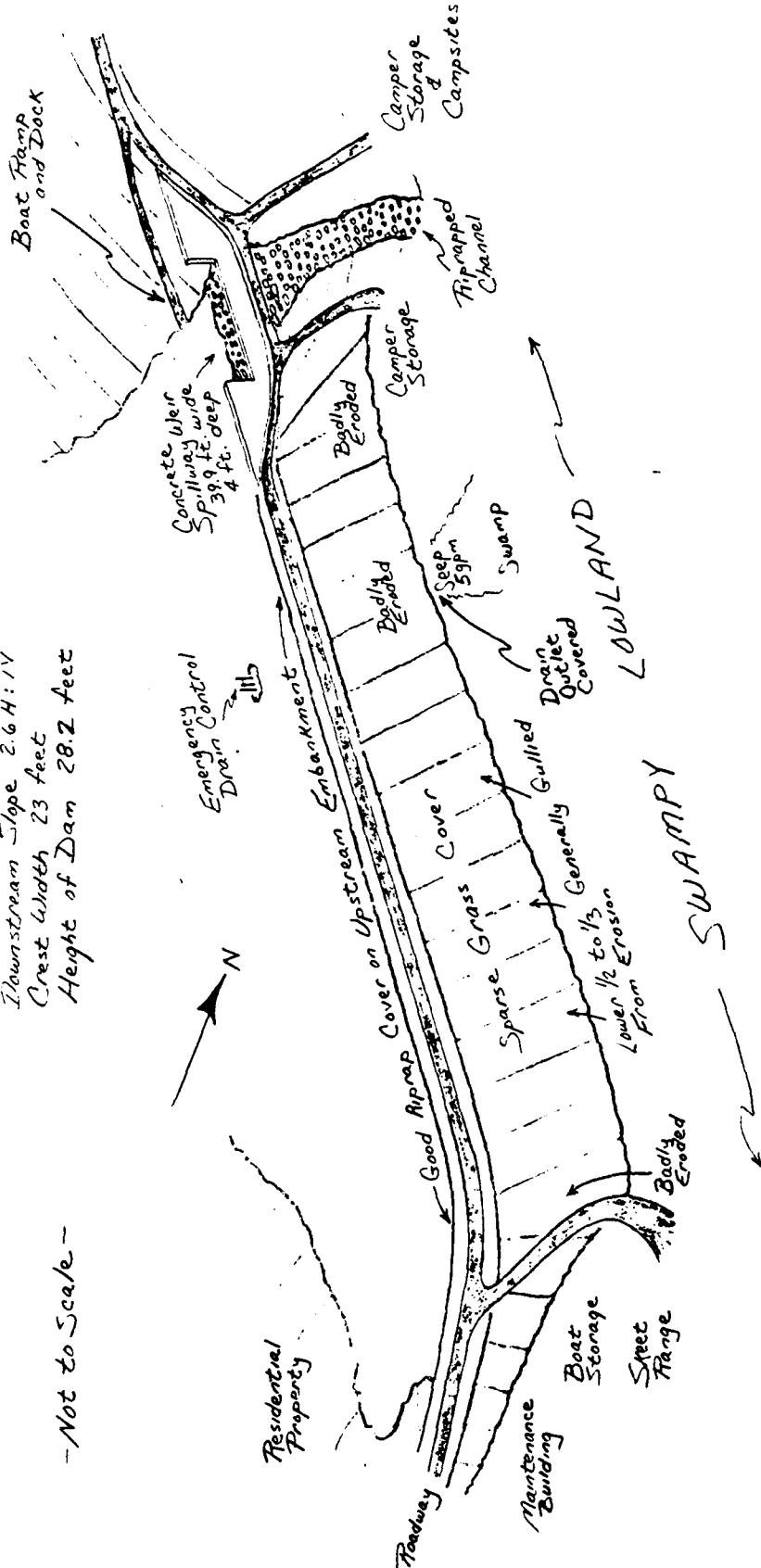
**Plate 2: Profile of Top of Dam**

**Plate 3: Typical Cross Section of Dam**

**NAME OF DAM: LAKE LAND'OR DAM**



Upstream Slope 4.34:1V  
Downstream Slope 2.64:1V  
Crest Width 23 feet  
Height of Dam 28.2 feet  
-Not to Scale -



FIELD SKETCH  
LAKE LAND'OR DAM, VIRGINIA  
Michael Baker, Jr., Inc.  
27 October 1980

DwH 10-80

PLATE I

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280  
Beaver, Pa. 15009

TOP OF DAM PROFILE LAKE LAND'OR  
LOOKING DOWNSTREAM

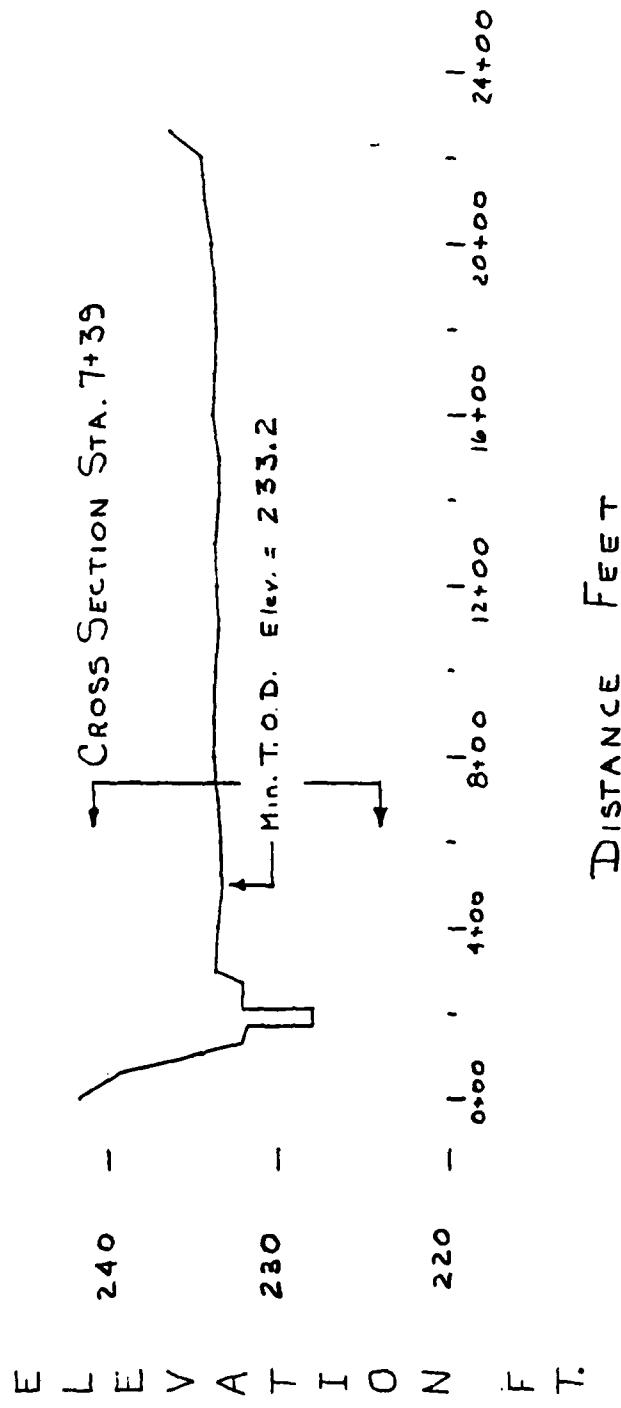


PLATE 2

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280  
Beaver, Pa. 15009

CROSS SECTION LAKE LAND, OR AT STATION 7+39

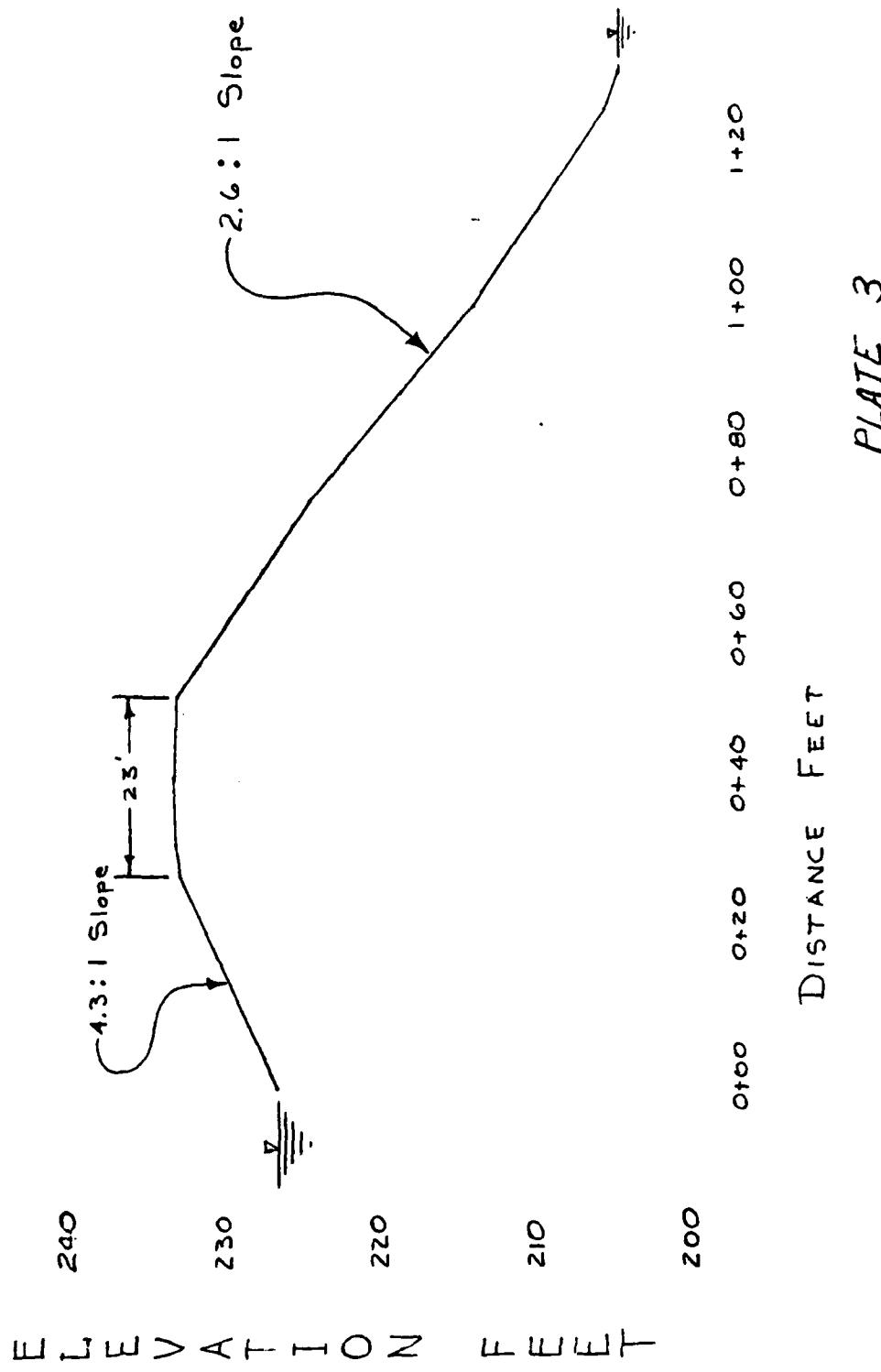


PLATE 3

**APPENDIX II**  
**PHOTOGRAPHS**

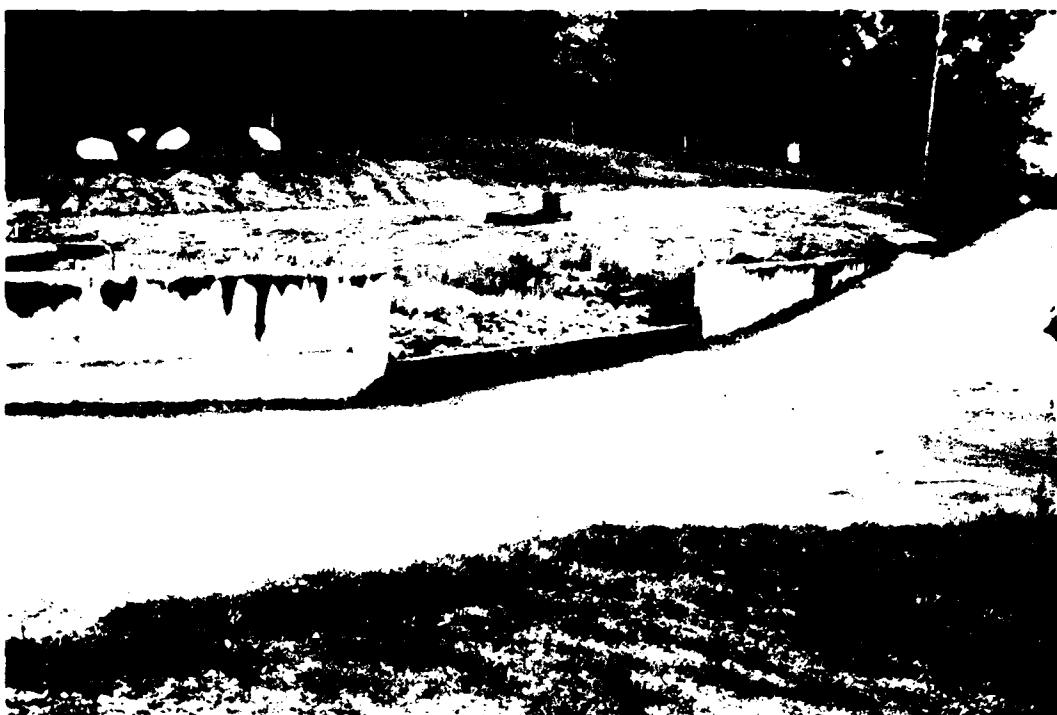
## CONTENTS

- Photo 1: Spillway and Left Abutment Area
- Photo 2: Camper Storage and Campground Immediately Downstream of Spillway
- Photo 3: Campground with Spillway in Background
- Photo 4: Right Abutment Area
- Photo 5: Riprap on Upstream Embankment, Emergency Drain Control and Support in Left Background
- Photo 6: Sparse Vegetation and Gullies from Erosion on Downstream Embankment
- Photo 7: Houses Downstream of Dam, in Plan on West Side of U.S. Route 1
- Photo 8: Bridge for U.S. Route 1 Downstream of Dam

Note: Photographs taken 27 October 1980.

NAME OF DAM: LAKE LAND'OR DAM

**LAKE LAND'OR DAM**



**PHOTO 1. Spillway and Left Abutment Area**



**PHOTO 2. Camper Storage and Campground Immediately  
Downstream of Spillway**

**LAKE LAND'OR DAM**



**PHOTO 3. Campground with Spillway in Background**



**PHOTO 4. Right Abutment Area**

**LAKE LAND'OR DAM**



**PHOTO 5. Riprap on Upstream Embankment, Emergency Drain Control and Support in Left Background**

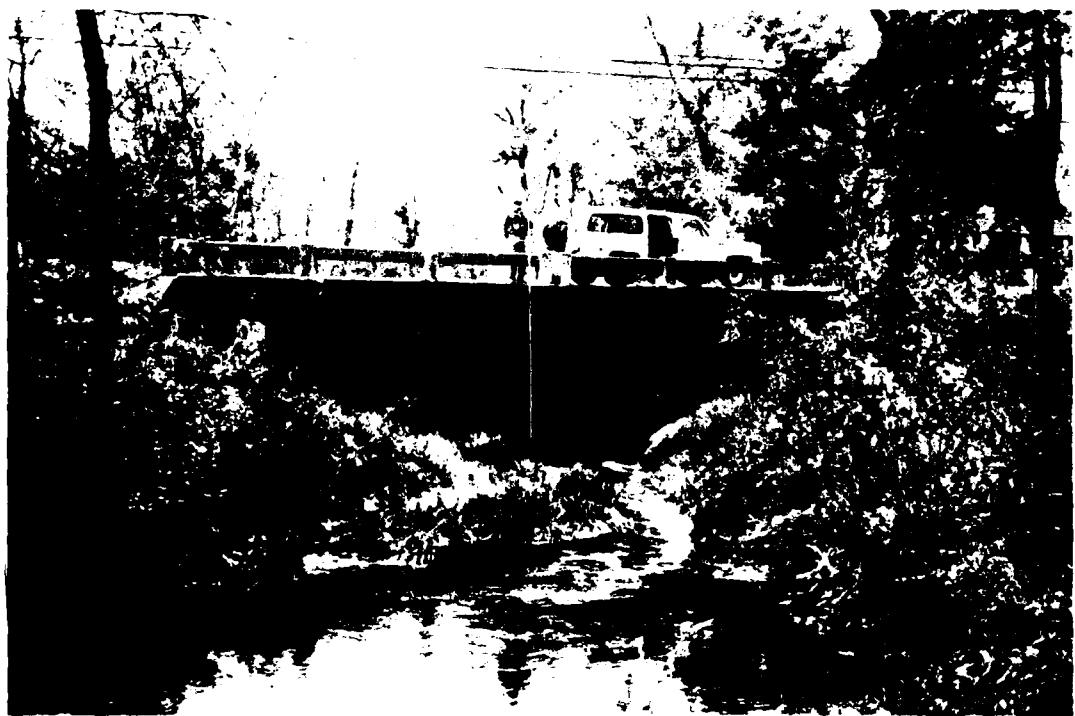


**PHOTO 6. Sparse Vegetation and Gullies from Erosion on Downstream Embankment**

**LAKE LAND'OR DAM**



**PHOTO 7. Houses Downstream of the Dam, in Plan on West Side of  
U. S. Route 1**



**PHOTO 8. Bridge for U. S. Route 1, Downstream of Dam**

APPENDIX III  
VISUAL INSPECTION CHECK LIST

Check List  
Visual Inspection  
Phase 1

Name of Dam Lake Land'or Dam County Caroline State Virginia Coordinates Lat. 3801.5  
Long. 7733.5

Date of Inspection 27 October 1980 Weather Clear Temperature 40-55° F.

Pool Elevation at Time of Inspection 227.0 ft. T.B.M.\* Tailwater at Time of Inspection 205.0 ft. T.B.M.

\*All elevations referenced to a Temporary Bench Mark located on the right side of the spillway crest. The assumed elevation is 228.0 ft.

Inspection Personnel:

Michael Baker, Jr., Inc.:

David Greenwood  
Larry Diday  
David Hupe

Virginia State Water Control Board:

Ed Constantine

Owner's Representatives:

Bill Benner - Developer's Representative

Mr. Robert Oberbrockling -  
Manager, Lake Land'or  
Property Owners Association.  
Meeting before inspection.

David W. Hupe Recorder

## EMBANKMENT

Name of Dam: LAKE LAND'OR DAM

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS		None observed. The ground surface of the embankment and abutments was generally dry.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE		None observed	

SLOUGHING OR EROSION OF  
EMBANKMENT AND ABUTMENT  
SLOPES

Vegetation on the downstream embankment is somewhat sparse, particularly on the lower half. The lower one half to one third of the downstream embankment is moderately eroded with numerous gullies, some as deep as two ft. A few small animal burrows are also present and small saplings have seeded into the downstream slope.

The downstream embankment directly above the emergency outlet is badly eroded.

The outer embankment materials were determined to consist of reddish-brown sandy silt with a trace of clay.

**EMBANKMENT**

Name of Dam: LAKE LAND'OR DAM

<b>VISUAL EXAMINATION OF</b>	<b>OBSERVATIONS</b>	<b>REMARKS OR RECOMMENDATIONS</b>
<b>VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST</b>	The vertical alignment of the crest varies by 1.0 ft. and the horizontal alignment appears to be good.	The riprap should be extended another 50 ft. onto the right upstream abutment.
<b>RIPRAP FAILURES</b>	The upstream embankment is totally riprapped with gneiss (large one ft. chunks choked off with smaller material). The riprap is generally in excellent condition.	
<b>JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM</b>	The contact areas of the embankment with the abutment are in generally good condition. Some minor erosion has occurred along the left side of the upstream embankment between the spillway and the left abutment.	Riprap on the upstream embankment should be extended another 50 ft. on the right side to better protect the abutment. In addition, more riprap should be added to the left of the spillway approach channel in the boat dock area.

## EMBANKMENT

Name of Dam: LAKE LAND'OR DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	A continually flowing, clear seep has developed near the outlet of the emergency drain, which has been covered over by sediment eroded from the embankment. Flow of this seepage was estimated to be in excess of five gallons per minute. No other seepage was observed.	The characteristics of this seep indicate that the discharge is seepage from the drain rather than seepage through the dam.
STAFF GAGE	A series of alternately colored markers are present on the structure that supports the emergency drain control, but there is no actual staff gage.	A staff gage should be installed to monitor reservoir levels above normal pool.
DRAINS	No evidence of an internal drainage system was found.	

Name of Dam: LAKE LAND' OR DAM

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	The lake drain structure was submerged at the time of inspection.	The inlet is assumed to be an 18 in. gate valve similar to Lake Heritage as referenced by the construction manager.
OUTLET STRUCTURE	The outlet for the lake drain was buried beneath material eroded from the downstream embankment.	The drain pipe size could not be confirmed but is assumed to be an 18 in. corrugated metal pipe as referenced by the construction manager.
OUTLET CHANNEL	There is no defined outlet channel. It flows to a flat swampy area.	The area around the emergency drain outlet should be excavated to uncover the outlet. The outlet should be protected by support walls or riprap to prevent future covering over. Positive drainage should be provided from the outlet when repaired.

Name of Dam: LAKE LAND'OR DAM

OUTLET WORKS

VISUAL EXAMINATION OF      OBSERVATIONS      REMARKS OR RECOMMENDATIONS

EMERGENCY GATE      An emergency drain is located approximately 600 ft. from the left abutment. A gate valve hand control is located approximately 75 ft. off-shore. The gate valve supporting tower and mechanism are badly corroded and very unstable and may not operate.

Name of Dam: LAKE LAND'OR DAM

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The spillway control section is a rectangular-shaped, reinforced concrete weir 39.9 ft. wide by 4.0 ft. deep by 0.73 ft. thick. Slight spalling of the concrete was observed.	A highwater mark is marked in the right concrete wall of the spillway and labeled Agnes. The mark is 2.96 ft. above the weir (elev. 230.96 T.B.M.).
APPROACH CHANNEL	The approach channel is riprapped with gneiss and in good condition. However, there is an insufficient amount of riprap on the left side. No obstructions or overgrowth choke the approach channel. A boat ramp and dock for general use is situated a short distance upstream from the spillway approach channel. Highly weathered gneiss is exposed on the left shoreline near the channel.	The boat dock situated just upstream of the spillway approach channel should be relocated to prevent any obstruction from occurring in the spillway during high flows. In addition, more riprap should be added to the left of the spillway approach channel for a distance of 70 ft. to prevent rapid erosion if the weir is overtopped.
DISCHARGE CHANNEL	The discharge channel immediately downstream of the weir is a paved concrete splash apron 1.7 ft. below the crest of the weir with a bottom width of approximately 40 ft. and side slopes of approximately 11.5H:1V. The concrete splash apron is approximately 31 ft. long. The splash apron is unobstructed and in good condition. The discharge channel downstream of the splash apron is riprapped and approximately 300 ft. long by 40 ft. wide. Some moderate storage areas near the channel.	The erosion on the right side of the spillway discharge channel should be inspected and proper size riprap installed. The outlet of the spillway discharge channel should be widened and all obstructions removed to prevent possible flooding of campsites and camper storage areas near the channel.

(Continued next page)

Name of Dam: LAKE LAND'OR DAM

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DISCHARGE CHANNEL (Continued)	erosion has occurred along the right side of the riprapped discharge channel. The discharge channel is narrow and obstructed near the outlet. Campers are stored immediately adjacent to the spillway discharge channel.	
BRIDGE AND PIERS	N/A	

Name of Dam: LAKE LAND'OR DAM

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	No monumentation or surveys were available.	
OBSERVATION WELLS	None present	
WEIRS	None present	
PIEZOMETERS	None present	
OTHER		

Name of Dam: LAKE LAND'OR DAM

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes surrounding the reservoir are very gentle and covered with a moderately thick cover of grass. An insignificant amount of minor erosion has occurred at the shoreline. Development along the shoreline consists of a few private boat docks scattered around the lake and a boat ramp and boat dock for general use located a short distance upstream from the spillway approach channel. A few homes are scattered sporadically along the lake shore.	
SEDIMENTATION	No serious sedimentation was apparent during the field investigation. Soundings indicate the lake bottom to be about 19 ft. below pool level at time of inspection.	

Name of Dam: LAKE LAND'OR DAM

DOWNTSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The area immediately downstream of the embankment is swampy and brush covered, especially in the area downstream of the outlets of the spillway discharge channel and emergency drain.	
SLOPES	The slope of the stream below the dam is extremely flat, approximately 0.1%, and the stream flows through swamps with heavy brush cover for about 1.5 mi. The absence of a distinct channel below the outlets of the spillway discharge channel and emergency drain appears to be a contributing factor to the swampy condition which now exists below the embankment.	
APPROXIMATE NO. OF HOMES AND POPULATION	Camper storage areas have been developed along both sides of the spillway discharge channel and campsite on the left side only. A skeet range, maintenance building, and boat storage area are located downstream of the right embankment.	Approximately 2.5 mi. downstream, at the U.S. Route 1 bridge, a housing development and trailer park are located on the left side of the river. Most of the structures are 30 ft. above the stream, but several houses are only 10 ft. above and could be damaged.
		Approximately 500 ft. upstream from South River, the stream flows through an 11 ft. steel plate arch under Campers Lane.

**APPENDIX IV**  
**GENERAL REFERENCES**

## GENERAL REFERENCES

1. Bureau of Reclamation, U.S. Department of the Interior, Design of Small Dams, A Water Resources Technical Publication, Revised Reprint, 1977.
2. Chow, Ven Te, Handbook of Applied Hydrology, McGraw - Hill Book Company, New York, 1964.
3. Chow, Ven Te, Open Channel Hydraulics, McGraw - Hill Book Company, New York, First Edition, 1959.
4. Commonwealth of Virginia, "Geologic-Map of Virginia," Department of Conservation and Economic Development, and Division of Mineral Resources, 1963.
5. HR 33, "Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations of 6 to 48 Hours," (1956).
6. King, Horace Williams and Brater, Ernest F., Handbook of Hydraulics, Fifth Edition, McGraw - Hill Book Company, New York, 1963.
7. Soil Conservation Service, "National Engineering Handbook - Section 4, Hydrology," U.S. Department of Agriculture, 1964.
8. Soil Conservation Service, "National Engineering Handbook - Section 5, Hydraulics," U.S. Department of Agriculture.
9. U.S. Army, Hydrologic Engineering Center, "Flood Hydrograph Package (HEC-1), Dam Safety Investigations, Users Manual," Corps of Engineers, Davis, California, September 1978.
10. U.S. Army, Hydrologic Engineering Center, "HEC-2 Water Surface Profiles, Users Manual," Corps of Engineers, Davis, California, October 1973.
11. U.S. Army, "Inventory of United States Dams," Corps of Engineers, 9 September 1978.
12. U.S. Army, Office of the Chief of Engineers, "Appendix D, Recommended Guidelines for Safety Inspection of Dams," National Program of Inspection of Dams, Volume 1, Corps of Engineers, Washington, D.C., May 1975.

NAME OF DAM: LAKE LAND'OR DAM

13. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-163 (Draft Engineering Manual), "Spillway and Freeboard Requirements for Dams, Appendix C, Hydrometeorological Criteria and Hyetograph Estimates," (August 1975).
14. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-188, "Engineering and Design, National Program of Inspection of Non-Federal Dams," Corps of Engineers, Washington, D.C., 30 December 1977.
15. U.S. Army, Office of the Chief of Engineers, Engineer Technical Letter No. ETL 1110-2-234, "Engineering and Design, National Program of Inspection of Non-Federal Dams, Review of Spillway Adequacy," Corps of Engineers, Washington, D.C., 10 May 1978.
16. U.S. Department of Commerce, "Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," Weather Bureau, Washington, D.C., May 1961.
17. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, "Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," Washington, D.C., June 1978.

NAME OF DAM: LAKE LAND'OR DAM

